SHEET (3)
Exergy: a measure of work potential

1- How does reversible work differ from useful work?

2- What final state will maximize the work output of a device?

3- Is the exergy of a system different in different environments?

4- Consider two geothermal wells whose energy contents are estimated to be the same. will the exergies of these wells necessarily be the same? explain.

5- What is the second-law efficiency? How does it differ from the first-law efficiency?

6- A heat engine receives heat from a source at 1500 K at a rate of 700 kJ/s, and it rejects the waste heat to a medium at 320 K. the measured power output of the heat engine is 320 kW, and the environment temperature is 25 °C, (a) determine the reversible power, (b)the rate of irreversibility, and (c) the second-law efficiency of this heat engine. (*Answers:(a) 550.7 kW, (b) 230.7 kW, (c) 58.1 percent*)

7- A freezer is maintained at -7 °C by removing heat from it at a rate of 80 kJ/min. The power input to the freezer is 0.5 kW, and the surrounding air is at 25 °C. Determine (a) the reversible power, (b) the irreversibility, and (c) the second-law efficiency of the freezer. (*Answers:(a) 0.16 kW, (b) 0.34 kW, (c) 32.0 percent*)

8- A piston-cylinder device initially contains 2 L of air at 100 kPa and 25 °C air is now compressed to a final state of 600 kPa and 150 °C. the useful work input is 1.2 kJ. Assuming the surroundings are at 100 kPa and 25 °C, determine (a) the exergy of the air at the initial and the final states, (b) the minimum work that must be supplied to accomplish this compression process, and (c) the second-law efficiency of this process. (*Answers:(a) 0, 0.171 kW, (b) 0.171 kW, (c) 14.3 percent*)

9- A 1.2 m^3 insulated rigid tank contains 2.13 kg of carbon dioxide at 100 kPa. Now paddle-wheel work is done on the system until the pressure in the tank rises to 120 kPa. Determine (a) the actual paddle-wheel work done during this process and (b) the minimum paddle-wheel work with which this process (between the same end states) could be accomplished. Take To = 298 K. (*Answers:(a) 87.0 kJ, (b) 7.74 kJ*)

10- Steam enters an adiabatic turbine at 6 Mpa, 600 °C, and 80 m/s and leaves at 50 kPa, 100 °C, and 140 m/s. if the power output of the turbine is 5 MW. Determine (a) the reversible power output and (b) the second-law efficiency of the turbine. Assume the surroundings to be at 25 °C. (*Answers:(a) 5.84 MW, (b) 85.6 percent*)

11- A hot water stream at 70 °C enters an adiabatic mixing chamber with a mass flow rate of 2 kg/s, where it is mixed with a stream of cold water at 20 °C. if the mixture leaves the chamber at 45 °C, determine (a) the mass flow rate of the cold water and (b) the exergy destroyed during this adiabatic mixing process. Assume all the streams are at a pressure of 350 kPa and the surroundings are at 25 °C. (*Answers:(a) 2.0 kg/s, (b) 15.5 kW*)

12- Steam is to be condensed in the condenser of a steam power plant at a temperature of 60 °C, with cooling water from a nearby lake that enters the tubes of the condenser at 15 °C at a rate of 140 kg/s and leaves at 25 °C. Assuming the condenser to be perfectly insulated, determine (a) the rate of condensation of the steam and (b) the rate of exergy destruction in the condenser. (*Answers:(a) 2.48 kg, (b) 694 kW*)

13- Consider natural gas, electric resistance, and heat pump heating systems. For a specified heating load, which one of these systems will do the job with the least irreversibility? Explain.